WHAT IS CLAIMED IS:

1. A microfabricated elastomeric structure, comprising:

an elastomeric block formed with microfabricated recesses therein, a portion of the elastomeric block deflectable when the portion is actuated.

Desired Result

2. The microfabricated elastomeric structure of claim 1 wherein the recesses have a width in the range of 0.01 μm to 1000 μm.

3. The microfabricated elastomeric structure of claim 1 wherein the recesses have a width in the range of 0.2 μm to 500 μm.

4. The microfabricated elastomeric structure of claim 1 wherein the recesses have a width in the range of 10 μm to 200 μm.

5. The microfabricated elastomeric structure of claim 1 wherein the recesses have a depth to height ratio of between about 0.1:1 and 100:1.

6. The microfabricated elastomeric structure of claim 1 wherein the recesses have a depth to height ratio of between about 1:1 and 50:1.

7. The microfabricated elastomeric structure of claim 1 wherein the recesses have a depth to height ratio of between about 2:1 and 20:1.

8. The microfabricated elastomeric structure of claim 1 wherein the recesses have a depth of between about 0.01 μm and 1000 μm.

9. The microfabricated elastomeric structure of claim 1 wherein the recesses have a depth of between about 0.2 μm and 250 μm.

10. The microfabricated elastomeric structure of claim 1 wherein the recesses have a depth of between about 2 μm and 20 μm.

11. The microfabricated elastomeric structure of claim 1 wherein the portion has a thickness of between about 0.01 μm and 1000 μm.

12. The microfabricated elastomeric structure of claim 1 wherein the portion has a thickness of between about 0.2 μm and 250 μm.

13. The microfabricated elastomeric structure of claim 1, wherein the portion has a thickness of between about 2 μm and 50 μm.

14. The microfabricated elastomeric structure of claim 1, wherein the portion responds linearly to an applied actuation force. Desired Result

15. The microfabricated elastomeric structure of claim 1, wherein the portion is actuated at a speed of 100 Hz or greater. D.R.

16. The microfabricated elastomeric structure of claim 1, wherein the structure contains substantially no dead volume when the portion is actuated.

17. The microfabricated elastomeric structure of claim 1 wherein:

the recesses comprise a first microfabricated channel and a second microfabricated channel; and

the portion comprises an elastomeric membrane deflectable into either of the first or second microfabricated channels when the membrane is actuated.

18 . A microfabricated elastomeric structure of claim 1 wherein;

the recesses comprise a first microfabricated channel and a first microfabricated recess; and

the portion comprises an elastomeric membrane deflectable into the first microfabricated channel when the membrane is actuated.

19. A microfabricated elastomeric structure of claim 18 wherein the first microfabricated recess comprises a second microfabricated channel.

20. The microfabricated elastomeric structure of claim 18 wherein the membrane is deflectable into the first channel when the first microfabricated recess is pressurized. D.R.

21. The microfabricated elastomeric structure of claim 18 wherein the membrane is deflectable into the first channel when the membrane is electrostatically actuated.

22. The microfabricated elastomeric structure of claim 21 wherein:

a first conductive portion is provided in the membrane; and

a second conductive portion is disposed on an opposite side of the first channel from the first conductive portion.

23. The microfabricated elastomeric structure of claim 22 wherein at least one of the first and second conductive portions comprises an intrinsically conductive elastomer.

24. The microfabricated elastomeric structure of claim 22 wherein at least one of the first and second conductive portions comprises an elastomer doped with a conductive material.

25. The microfabricated elastomeric structure of claim 24 wherein the conductive material comprises fine metal particles.

26. The microfabricated elastomeric structure of claim 24 wherein the conductive material comprises carbon.

27. The microfabricated elastomeric structure of claim 18 wherein the membrane is deflectable into the first channel when the membrane is magnetically actuated.

28. The microfabricated elastomeric structure of claim 27 wherein:

a magnetic portion is provided in the membrane; and

means for applying a magnetic field is disposed on an opposite side of the first channel from the magnetic portion.

29. The microfabricated elastomeric structure of claim 27 wherein:

a magnetic portion is provided in the membrane; and

means for applying a magnetic field is disposed on the same side of the first channel as the magnetic portion.

30. The microfabricated elastomeric structure of claim 28 wherein the means for applying a magnetic field comprises a magnet.

31. The microfabricated elastomeric structure of claim 28 wherein the means for applying a magnetic field comprises a magnetic coil.

32. The microfabricated elastomeric structure of claim 28 wherein the means for applying a magnetic field comprises a microfabricated magnetic coil.

33. The microfabricated elastomeric structure of claim 28 wherein the magnetic portion comprises an intrinsically magnetic elastomer.

34. The microfabricated elastomeric structure of claim 28 wherein the magnetic portion comprises an elastomer doped with a magnetic material.

35. The microfabricated elastomeric structure of claim 34 wherein the dopant comprises a magnetically polarizable material.

36. The microfabricated elastomeric structure of claim 34 wherein the dopant comprises a permanently magnetized material.

37. The microfabricated elastomeric structure of claim 27 wherein:

a permanently magnetized portion is provided in the membrane; and

means for applying a magnetic field is disposed on the same side of the first channel from the permanently magnetized portion.

38. The microfabricated elastomeric structure of claim 27 wherein:

a permanently magnetized portion is provided in the membrane; and

means for applying a magnetic field is disposed on an opposite side of the first channel from the permanently magnetized portion.

39. The microfabricated elastomeric structure of claim 19, wherein the first and second microfabricated channels cross over one another, but do not intersect.

40. The microfabricated elastomeric structure of claim 19, wherein the first and second microfabricated channels are disposed at an angle to one another, but do not contact one another.

41. The microfabricated elastomeric structure of claim 19 wherein the first and second microfabricated channels both pass through the elastomeric structure.

42. The microfabricated elastomeric structure of claim 19 wherein the second microfabricated channel passes through the elastomeric structure and the first microfabricated channel passes along a surface of the elastomeric structure.

43. The microfabricated elastomeric structure of claim 42, further comprising:

a planar substrate positioned adjacent the surface of the elastomeric structure along which the first microfabricated channel passes.

44. The microfabricated elastomeric structure of claim 18, further comprising:

second and third recesses separated from the first channel by second and third membranes respectively, which are deflectable into the first channel.

45. The microfabricated elastomeric structure of claim 19, further comprising:

third and fourth channels disposed parallel to the second channel, wherein the second, third and fourth channels are separated from the first channel by first, second and third membranes respectively, deflectable into the first channel.

46. The microfabricated elastomeric structure of claim 45, wherein the first, second, and third membranes are deflectable into the first channel when the second, third and fourth channels, respectively, are pressurized.

47. The microfabricated elastomeric structure of claim 44 wherein the first, second, and third membranes are deflectable into the first channel when the membranes are eletrostatically actuated.

48. The microfabricated elastomeric structure of claim 47, wherein,

first, second and third conductive portions are provided in the respective membranes; and

fourth, fifth and sixth conductive portions are provided opposite the respective first, second and third conductive portions such that the first and fourth, second and fifth and third and sixth conductive portions are disposed on opposite sides of the first channel.

49. The microfabricated elastomeric structure of claim 44, wherein the membranes are deflectable into the first channel when the membranes are magnetically actuated.

50. The microfabricated elastomeric structure of claim 49, wherein,

first, second and third magnetic portions are provided in the respective first, second and third membranes; and

means for applying a magnetic field is disposed on an opposite side of the first channel from the magnetic portion.

51. The microfabricated elastomeric structure of claim 49, wherein,

first, second and third permanently magnetized portions are provided in the respective first, second and third membranes; and

means for applying a magnetic field is disposed on the same side of the first channel from the magnetic portion.

52. The microfabricated elastomeric structure of claim 49, wherein,

first, second and third permanently magnetized portions are provided in the respective first, second and third membranes; and

means for applying a magnetic field is disposed on an opposite side of the first channel from the magnetic portion..

53. The microfabricated elastomeric structure of claim 19 further comprising a third microfabricated channel parallel to the first channel, the second channel having both wide and narrow portions disposed along its length, with a wide portion being disposed adjacent the first channel and a narrow portion being disposed adjacent the third channel.

54. The microfabricated elastomeric structure of claim 53, wherein

pressurizing the second channel causes the membrane separating the second channel from the first channel to be deflected into the first channel but does not cause the membrane separating the third channel from the second channel to be deflected into the third channel.

55. The microfabricated elastomeric structure of claim 18 wherein the membrane has a curved bottom surface such that the top of the first channel is curved.

56. The microfabricated elastomeric structure of claim 18 wherein at least one of a bottom surface of the membrane and a top surface of the first channel bear protrusions.

57. A microfabricated elastomeric structure comprising:

an elastomeric block;

a first channel and a second channel separated by a separating portion of the elastomeric structure; and

a microfabricated recess in the elastomeric block adjacent to the separating portion such that the separating portion may be actuated to deflect into the microfabricated recess.

58. The microfabricated elastomeric structure of claim 57 wherein the microfabricated recess experiences a reduced pressure which causes the separating portion to deflect into the microfabricated recess. Des. Req.

59. The microfabricated elastomeric structure of claim 57 wherein the separating portion is deflectable into the microfabricated recess when the separating portion is electrostatically actuated. -28

60. The microfabricated elastomeric structure of claim 59 wherein:

a first conductive portion is provided in the separating portion; and

a second conductive portion is disposed on an opposite side of the microfabricated recess from the first conductive portion.

61. The microfabricated elastomeric structure of claim 57 wherein the separating portion is deflectable into the first channel when the separating portion is magnetically actuated.

62. The microfabricated elastomeric structure of claim 61 wherein:

a first magnetic portion is provided in the separating portion; and

means for producing a magnetic field is disposed on an opposite side of the microfabricated recess from the first magnetic portion.

63. The microfabricated elastomeric structure of claim 61 wherein:

a first permanently magnetized portion is provided in the separating portion; and

means for producing a magnetic field is disposed on an opposite side of the microfabricated recess from the first permanently magnetized portion.

64. The microfabricated elastomeric structure of claim 61 wherein:

a first permanently magnetized portion is provided in the separating portion; and

means for producing a magnetic field is disposed on the same side of the microfabricated recess from the first permanently magnetized portion.

65. The elastomeric structure of claim 57, further comprising a planar substrate positioned adjacent a surface of the elastomeric structure along which the first and second channels pass.

66. The microfabricated elastomeric structure of claim 57 wherein deflection of the separating portion opens a passageway between the first and second channels.

67. The elastomeric structure of claim 57, wherein first recess has a wide segment disposed adjacent to the portion.

68. The microfabricated elastomeric structure of claim 1 wherein the elastomeric structure comprises a material selected from the group consisting of:

polyisoprene, polybutadiene, polychloroprene, polyisobutylene, poly(styrene-butadiene-styrene), the polyurethanes, and silicones.

69. The microfabricated elastomeric structure of claim 1 wherein the elastomeric structure comprises a material selected from the group consisting of:

poly(bis(fluoroalkoxy)phosphazene) (PNF, Eypel-F), poly(carborane-siloxanes) (Dexsil), poly(acrylonitrile-butadiene) (nitrile rubber), poly(1-butene), poly(chlorotrifluoroethylene-vinylidene fluoride) copolymers (Kel-F), poly(ethyl vinyl ether), poly(vinylidene fluoride), poly(vinylidene fluoride – hexafluoropropylene) copolymer (Viton).

70. The microfabricated elastomeric structure of claim 1 wherein the elastomeric structure comprises a material selected from the group consisting of:

elastomer compositions of polyvinylchloride (PVC), polysulfone, polycarbonate, polymethylmethacrylate (PMMA), or polytertrafluoroethylene (Teflon).

71. The microfabricated elastomeric structure of claim 68 wherein the elastomeric structure comprises a material selected from the group consisting of:

polydimethylsiloxane (PDMS) such as General Electric RTV 615, Dow Chemical Corp. Sylgard 182, 184, or 186, and aliphatic urethane diacrylates such as Ebecryl 270 or Irr 245 from UCB Chemicals.

72. The microfabricated elastomeric structure of claim 43 wherein the planar substrate is glass.

73. The microfabricated elastomeric structure of claim 43 wherein the planar substrate is an elastomeric material.

74. A microfabricated elastomeric structure of claim 18 wherein;

the first microfabricated channel is T-shaped and includes a stem in fluid communication with a first branch and a second branch;

the elastomeric membrane overlies and is deflectable into the first branch; and

the elastomeric structure further comprises a second recess overlying the second branch such that a second elastomeric membrane is deflectable into the second branch when the membrane is actuated, such that a flow of fluid into the stem may be directed into one of the first branch and the second branch by actuating the second elastomeric membrane and the first elastomeric membrane, respectively.

METHODS OF ACTUATING

75. A method of actuating an elastomeric structure comprising:

providing an elastomeric block formed with first and second microfabricated recesses therein, the first and second microfabricated recesses separated

by a membrane portion of the elastomeric block deflectable into one of the first and second recesses in response to an actuation force; and

applying an actuation force to the membrane portion such that the membrane portion is deflected into one of the first and the second recesses.

76. The method of claim 75 wherein the step of applying an actuation force comprises applying a pressure to the second microfabricated recess to deflect the membrane portion into the first microfabricated recess.

77. The method of claim 75 wherein the step of applying an actuation force comprises applying an electrical field to attract a conductive portion of the membrane into the first microfabricated recess.

78. The method of claim 75 wherein the step of applying an actuation force comprises applying a magnetic field to attract a magnetically polarizable portion of the membrane into the first microfabricated recess.

79. The method of claim 75 wherein the step of applying an actuation force comprises applying a magnetic field to attract a permanently magnetized portion of the membrane into the first microfabricated recess.

80. The method of claim 75 wherein the step of applying an actuation force comprises applying a magnetic field to repel a permanently magnetized portion of the membrane into the first microfabricated recess.

valve.

81. A method of controlling fluid or gas flow through an elastomeric structure comprising:

providing an elastomeric structure having a first microfabricated channel and a first microfabricated recess, the first microfabricated channel and the first microfabricated recess separated by a membrane deflectable into the first channel;

passing a fluid or gas flow through the first channel; and

deflecting the membrane into the first channel.

82. The method of claim 81 wherein the membrane is deflected into the first channel by increasing pressure within the microfabricated recess.

83. The method of claim 82 wherein pressure is increased in the first microfabricated recess by a chemical reaction occurring with in the first microfabricated recess.

84. The method of claim 83 wherein the chemical reaction is electrolysis.

85. The method of claim 82 wherein the increased pressure is caused by electrostatic actuation of a bellows structure in fluid communication with the first microfabricated recess.

86. The method of claim 83 wherein the increased pressure is caused by magnetic actuation of a bellows structure in fluid communication with the first microfabricated recess.

87. The method of claim 82 wherein the increased pressure within the first microfabricated recess arises due to an electrokinetic flow within the first microfabricated recess.

88. The method of claim 81, further comprising:
providing a first conductive portion in the membrane;
providing a second conductive portion such that the first and second conductive portions are disposed on opposite sides of the first channel; and
applying a voltage to the first and second conductive portions such that the membrane is deflected into the first channel by an attractive electrostatic force.

89. The method of claim 81 further comprising:
providing a magnetically polarizable portion in the membrane; and
applying a magnetic field across the first channel such that the membrane is deflected into the first channel by an attractive magnetic force.

90. The method of claim 81 further comprising:
providing a permanently magnetized portion in the membrane; and
applying a magnetic field across the first channel such that the membrane is deflected into the first channel by an attractive magnetic force.

91. The method of claim 81 further comprising:

providing a permanently magnetized portion in the membrane; and

applying a magnetic field such that the membrane is deflected into the first channel by a repulsive magnetic force.

Valve

92. A method of controlling fluid ~~or~~ gas flow through an elastomeric structure comprising:

providing an elastomeric block, the elastomeric block having first, second, and third microfabricated recesses, and the elastomeric block having a first microfabricated channel passing therethrough, the first, second and third microfabricated recesses separated from the first channel by respective first, second and third membranes deflectable into the first channel; and

deflecting the first, second and third membranes into the first channel in a repeating sequence to peristaltically pump a flow of fluid through the first channel.

93. The method of claim 92 wherein the first, second and third membranes are deflected into the first channel by increasing pressure within the first, second and third channels.

94. The method of claim 92 further comprising:

providing first, second and third conductive portions in respective first, second and third membranes;

providing a fourth, fifth and sixth second conductive portion opposite the respective first, second and third conductive portions such that the first and fourth, second and fifth, and third and sixth conductive portions are disposed on opposite sides of the first channel; and

applying in a repeated sequence voltage to the first and fourth, second and fifth, and third and sixth conductive portions such that the membranes are deflected into the first channel by an attractive electrostatic force.

95. The method of claim 92 further comprising:

providing first, second and third magnetically polarizable portions in the first, second and third membranes, respectively;

applying in a repeated sequence a magnetic field to the first, second, and third magnetically polarizable portions such that the first, second, and third membranes are deflected into the first channel by an attractive magnetic force.

96. The method of claim 92 further comprising:

providing first, second and third permanently magnetized portions in the first, second and third membranes, respectively;

applying in a repeated sequence a magnetic field to the first, second, and third permanently magnetized portions such that the first, second, and third membranes are deflected into the first channel by an attractive magnetic force.

97. The method of claim 92 further comprising:

providing first, second and third permanently magnetized portions in the first, second and third membranes, respectively;

applying in a repeated sequence a magnetic field to the first, second, and third permanently magnetized portions such that the first, second, and third membranes are deflected into the first channel by an repulsive magnetic force.

98. A method of controlling fluid or gas flow through an elastomeric structure comprising:

providing an elastomeric block having a first microfabricated channel and a second microfabricated channel separated by a separating portion, a first microfabricated recess adjacent to the separating portion;

passing a fluid or gas flow through the first channel; and

deflecting the separating portion into the first microfabricated recess, thereby creating a passageway between the first microfabricated channel and the second microfabricated channel.

99. The method of claim 98 wherein the separating portion is deflected into the first microfabricated recess by decreasing pressure within the first microfabricated recess.

100. The method of claim 98, further comprising:

providing a first conductive portion in the separating portion;

providing a second conductive portion such that the first and second conductive portions are disposed on opposite sides of the first microfabricated recess; and

applying a voltage to the first and second conductive portions such that the separating portion is deflected into the first microfabricated recess by an attractive electrostatic force.

101. The method of claim 98 further comprising:

providing a magnetically polarizable portion in the separating portion; and

applying a magnetic field across the first microfabricated recess such that the membrane is deflected into the first microfabricated recess by an attractive magnetic force.

102. The method of claim 98 further comprising:

providing a permanently magnetized portion in the separating portion; and

applying a magnetic field across the first microfabricated recess such that the membrane is deflected into the first microfabricated recess by an attractive magnetic force.

103. The method of claim 98 further comprising:

providing a permanently magnetized portion in the membrane; and

applying a magnetic field such that the membrane is deflected into the first microfabricated recess by a repulsive magnetic force.

104. A method of actuating a microfabricated elastomeric structure comprising:

providing an elastomeric structure having first and second microfabricated conductive portions, at least one of the first and the second microfabricated conductive portions deflectable when an electrical charge is supplied to the two microfabricated conductive portions; and

applying a voltage to the two microfabricated conductive portions, thereby generating an attractive force therebetween such that at least one of the microfabricated conductive portions is deflected.

105. A method of actuating a microfabricated elastomeric structure comprising:

providing an elastomeric structure having a magnetic portion deflectable when a magnetic field is applied; and

applying a magnetic field to the magnetic portion thereby generating an actuating force on the magnetic portion such that the magnetic portion is deflected.

106. The method of claim 105 wherein the magnetic portion is composed of a magnetically polarizable material.

107. The method of claim 105 wherein the magnetic portion is composed of a permanently magentized material.

108. The method of claim 105 wherein the permanently magnetized material is created by exposing a material to a strong magnetic field.

109. A method of microfabricating an elastomeric structure, comprising:

microfabricating a first elastomeric layer;

microfabricating a second elastomeric layer;

positioning the second elastomeric layer on top of the first elastomeric layer; and

bonding a bottom surface of the second elastomeric layer onto a top surface of the first elastomeric layer.

110. The method of claim 109 wherein the first and second elastomeric layers are microfabricated by replication molding.

111. The method of claim 109 wherein the first and second elastomeric layers are microfabricated by laser cutting.

112. The method of claim 109 wherein the first and second elastomeric layers are microfabricated by chemical etching.

113. The method of claim 113 wherein the first and second elastomeric layers are microfabricated by sacrificial layer methods.

114. The method of claim 109 wherein the first and second elastomeric layers are microfabricated by injection molding.

115. The method of claim 109 wherein:

the first elastomeric layer is fabricated on a first micromachined mold having at least one raised protrusion which forms at least one recess in the bottom of the first elastomeric layer; and

the second elastomeric layer is fabricated on a second micromachined mold having at least one raised protrusion which forms at least one recess in the bottom of the first elastomeric layer.

116. The method of claim 115 wherein the first micromachined mold has at least one first raised protrusion which forms at least one first channel in the bottom surface of the first elastomeric layer.

117. The method of claim 116 wherein the second micromachined mold has at least one second raised protrusion which forms at least one second channel in the bottom surface of the second elastomeric layer.

118. The method of claim 117 wherein a bottom surface of the second elastomeric layer is bonded onto a top surface of the first elastomeric layer such that the at least one second channel is enclosed between the first and second elastomeric layers.

119. The method of claim 116 further comprising positioning the first elastomeric layer on top of a planar substrate such that the at least one first channel is enclosed between the first elastomeric layer and the planar substrate.

120. The method of claim 116 wherein a hermetic seal is formed between the bottom of the first layer and the top of the planar substrate.

121. The method of claim 109 further comprising:

microfabricating an nth elastomeric layer; and

bonding the bottom surface of the (n-1)th elastomeric layer onto a top surface of the nth elastomeric layer.

122. The method of claim 109 further comprising:

sequential addition of further elastomeric layers, whereby each layer is added by:

microfabricating a successive elastomeric layer; and

bonding the bottom surface of the successive elastomeric layer onto a top surface of the elastomeric structure.

123. A method of microfabricating an elastomeric structure comprising:

providing a first microfabricated elastomeric structure;

providing a second microfabricated elastomeric structure; and

bonding a surface of the first elastomeric structure onto a surface of the second elastomeric structure.

124. The method of claim 109 wherein at least one of the first elastomeric layer and the second elastomeric layer are fabricated from a material selected from the group consisting of:

elastomeric compositions of polyisoprene, polybutadiene, polychloroprene, polyisobutylene, poly(styrene-butadiene-styrene), the polyurethanes, and silicones.

125. The method of claim 109 wherein at least one of the first elastomeric layer and the second elastomeric layer are fabricated from a material selected from the group consisting of:

poly(bis(fluoroalkoxy)phosphazene) (PNF, Eypel-F), poly(carborane-siloxanes) (Dexsil), poly(acrylonitrile-butadiene) (nitrile rubber), poly(1-butene), poly(chlorotrifluoroethylene-vinylidene fluoride) copolymers (Kel-F), poly(ethyl vinyl ether), poly(vinylidene fluoride), poly(vinylidene fluoride – hexafluoropropylene) copolymer (Viton).

126. The method of claim 109 wherein at least one of the first elastomeric layer and the second elastomeric layer are fabricated from a composition selected from the group consisting of:

polyvinylchloride (PVC), polysulfone, polycarbonate, polymethylmethacrylate (PMMA), or polytertrafluoroethylene (Teflon).

127. The method of claim 124 wherein at least one of the first elastomeric layer and the second elastomeric layer are fabricated from a material selected from the group consisting of polydimethylsiloxane (PDMS) such as General Electric RTV 615, Dow Chemical Corp. Sylgard 182, 184, or 186, and aliphatic urethane diacrylates such as Ebecryl 270 or Irr 245 from UCB Chemicals.

128. The method of claim 109 wherein the first elastomeric layer has an excess of a first chemical species and the second elastomeric layer has an excess of a second chemical species.

129 . The method of claim 128 wherein the elastomeric layers comprise thermoset elastomers which are bonded together by heating above an elastic/plastic transition temperature of at least one of the first and second elastomeric layers.

130. The method of claim 128 wherein the first and second chemical species comprise different molecules.

131. The method of claim 128 wherein the first and second chemical species comprise different polymer chains.

132. The method of claim 128 wherein the first and second chemical species comprise different side groups on the same type of polymer chains.

133. The method of claim 128 wherein the first chemical species forms bonds with the second chemical species when at least one chemical species is activated.

134. The method of claim 133 wherein the at least one chemical species is activated by light.

135. The method of claim 133 wherein the at least one chemical species is activated by heat.

136. The method of claim 133 wherein the at least one chemical species is activated by the addition of a third chemical species.

137. The method of claim 136 wherein the at least one chemical species diffuses through the elastomer structure.

138. The method of claim 128 wherein the first and second elastomeric layers are formed of different elastomeric materials.

139. The method of claim 128 wherein the first and second elastomeric layers are initially composed of the same elastomeric material, and an additional elastomeric material is added to one of the first and second layers.

140. The method of claim 128 wherein the first and second elastomeric layers are composed of the same component materials, but differ in the ratio in which the component materials are mixed together.

141. The method of claim 140 wherein each of the elastomeric layers is made of two-part silicone.

142. The method of claim 141 wherein each elastomeric layer comprises an addition cure elastomer system.

143. The method of claim 141 wherein the silicone comprises two different reactive groups and a catalyst.

144. The method of claim 143 wherein the first reactive group comprises silicon hydride moieties, the second reactive group comprises vinyl moieties, and the catalyst comprises platinum.

145. The method of claim 144 wherein each elastomeric layer comprises G.E. RTV 615.

146. The method of claim 145 wherein the first elastomeric layer is mixed with a ratio of less than 10A:1B (excess Si-H groups) and the second elastomeric layer is mixed with a ratio of more than 10A:1B (excess vinyl groups).

147. The method of claim 146 wherein the first elastomeric layer has a ratio of 3A:1B (excess Si-H groups) and the second elastomeric layer has a ratio of 30A:1B (excess vinyl groups).

148. The method of claim 128 wherein each of the elastomeric layers are made of polyurethane.

149. The method of claim 148 wherein the polyurethane comprises Ebecryl 270 or Irr 245 from UCB Chemicals.

150. The method of claim 109 wherein the first and second elastomeric layers are made of the same material.

151. The method of claim 150 wherein at least one of the first and second elastomeric layers are incompletely cured.

152. The method of claim 150 wherein both the first and second elastomeric layers comprise a crosslinking agent.

153. The method of claim 152 wherein the crosslinking agent is activated by light.

154. The method of claim 152 wherein the crosslinking agent is activated by heat.

155. The method of claim 152 wherein the crosslinking agent is activated by an additional chemical species.

156. The method of claim 150 wherein the elastomeric layers comprise thermoset elastomers which are bonded together by heating above an elastic/plastic transition temperature of at least one of the first and second elastomeric layers.

157. The method of claim 109 wherein the first and second layers are bonded by a layer of adhesive.

158. The method of claim 157 wherein the adhesive comprises an uncured elastomer which is cured to bond the first and second elastomeric layers together.

159. The method of claim 158 wherein the adhesive comprises the same material as at least one of the first or second elastomeric layers.

160. The method of claim 109 wherein at least one of the elastomeric layers further comprises a conductive portion.

161. The method of claim 160 wherein the conductive portion is made by metal deposition.

162. The method of claim 161 wherein the conductive portion is made by sputtering.

163. The method of claim 161 wherein the conductive portion is made by evaporation.

164. The method of claim 161 wherein the conductive portion is made by electroplating.

165. The method of claim 161 wherein the conductive portion is made by electroless plating.

166. The method of claim 161 wherein the conductive portion is made by chemical epitaxy.

167. The method of claim 160 wherein the conductive portion is made by made by carbon deposition.

168. The method of claim 167 wherein the conductive portion is made by mechanically rubbing material directly onto the elastomeric layer.

169. The method of claim 167 wherein the conductive portion is made by exposing the elastomer to a solution of carbon particles in solvent.

170. The method of claim 169 wherein the solvent causes swelling of the elastomer.

171. The method of claim 169 wherein the elastomer comprises silicone and the solvent comprises a chlorinated solvent.

172. The method of claim 167 wherein the conductive portion is made by electrostatic deposition.

173. The method of claim 167 wherein the conductive portion is made by a chemical reaction producing carbon.

174. The method of claim 160 wherein the conductive portion is made by:

patterning a thin layer of metal on a flat substrate;

adhering the elastomeric layer onto the flat substrate; and

peeling the elastomeric layer off the flat substrate, such that the metal sticks to the elastomeric layer and comes off the flat substrate.

175. The method of claim 174 wherein the adhesion of the metal to the flat substrate is weaker than the adhesion of the metal to the elastomer.

176. Method of claim 160 wherein the conductive portion is patterned.

177. The method of claim 176 wherein the conductive portion is patterned by masking a surface of the conductive portion with a patterned sacrificial material.

178. The method of claim 176 wherein the conductive portion is patterned by:

depositing a sacrificial material on one of the elastomeric layers,

patterning the sacrificial material,

depositing a thin coat of conductive material thereover, and

removing the sacrificial material.

179. The method of claim 176 wherein the conductive portion is patterned by masking the surface with a shadow mask.

180. The method of claim 179 wherein the conductive portion is patterned by:

positioning a shadow mask adjacent to an elastomeric layer;

depositing a thin coat of conductive material through apertures in the shadow mask; and

removing the shadow mask.

181. The method of claim 176 wherein the conductive portion is patterned by etching.

182. The method of claim 181 wherein the conductive portion is patterned by:

depositing a mask layer onto one of the elastomeric layers;

patterning the mask layer;

etching the conductive portion through holes in the mask layer; and

removing the mask layer.

183. The method of claim 160 wherein the conductive portion is produced by doping the elastomer with a conductive material.

184. The method of claim 183 wherein the conductive material comprises a metal.

185. The method of claim 183 wherein the conductive material comprises carbon.

186. The method of claim 183 wherein the conductive material comprises a conductive polymer.

187. The method of claim 183 wherein the elastomer used is inherently conductive.

188. The method of claim 160 further comprising sealing the microfabricated elastomeric structure onto a flat substrate, wherein the flat substrate comprises at least one conductive portion.

189. The method of claim 188 wherein the flat substrate is covered by an insulating layer.

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190. The method of claim 54 wherein at least one of the first or second elastomeric layers comprises a magnetic portion.

191. The method of claim 190 wherein the magnetic portion is composed of an intrinsically magnetic elastomer.

192. The method of claim 190 wherein the magnetic portion is composed of an elastomer doped with a magnetic material.

193. The method of claim 192 wherein the magnetic dopant is a magnetically polarizeable material.

194. The method of claim 193 wherein the magnetic dopant is fine iron particles.

195. The method of claim 192 wherein the magnetic dopant is a permanently magnetized material.

196. The method of claim 195 wherein the permanently magnetized material is NdFeB or SmCo magnetized by exposure to a high magnetic field.

197. The method of claim 190 wherein pieces of magnetic material are relatively large compared with the size of the magnetic portion are incorporated into the elastomer.

198. The method of claim 197 wherein the magnetic material is a magnetically polarizeable material.

199. The method of claim 198 wherein the magnetic material is iron.

200. The method of claim 197 wherein the magnetic material is permanently magnetized.

201. The method of claim 200 wherein the permanently magnetized material is NdFeB or SmCo magnetized by exposure to a high magnetic field.

202. The method of claim 190 further comprising providing a structure capable of generating a switchable magnetic field, disposed adjacent to said magnetic portion, such that the application of said magnetic field to the elastomeric structure causes the generation of a force on the magnetic portion.

203. The method of claim 202 wherein the structure generating the magnetic field is a magnet coil.

204. The method of claim 202 wherein the structure generating the magnetic field is a substrate with at least one microfabricated magnet coil disposed thereon.

205. A method of microfabricating an elastomeric structure, comprising:
forming a first elastomeric layer on a substrate;
curing the first elastomeric layer;
patterning a first sacrificial layer over the first elastomeric layer;

forming a second elastomeric layer over the first elastomeric layer, thereby encapsulating the first patterned sacrificial layer between the first and second elastomeric layers;

curing the second elastomeric layer; and

removing the first patterned sacrificial layer selective to the first elastomeric layer and the second elastomeric layer, thereby forming at least one first recess between the first and second layers of elastomer.

206. The method of claim 205 further comprising patterning a second sacrificial layer over the substrate prior to forming the first elastomeric layer, such that the second patterned sacrificial layer is removed during removal of the first patterned sacrifical layer to form at least one recess along a bottom of the first elastomeric layer.

207. The method of claim 205 further comprising:

patterning a second sacrificial layer over the second elastomeric layer;

forming a third elastomeric layer over the second elastomeric layer, thereby encapsulating the second patterned sacrificial layer between the second and third elastomeric layers; and

curing the third elastomeric layer such that the second patterned sacrificial layer is removed during removal of the first patterned sacrifical layer to form a recess between the second and third elastomeric layers.

208. The method of claim 205 further comprising:

patterning an (n-1)th sacrifical layer over the nth elastomer layer;

forming a (n+1)th elastomeric layer over the (n-1)th patterned sacrifical layer; and

bonding the bottom surface of the (n-1)th elastomeric layer onto a top surface of the nth elastomeric layer, thereby encapsulating the (n-1)th patterned sacrificial layer between the nth and (n+1)th elastomeric layers; and

curing the (n+1) elastomeric layer such that the (n-1)th patterned sacrificial layer is removed during removal of the first patterned sacrifical layer to form a recess between the nth and (n+1)th elastomeric layers.

209. The method of claim 205 wherein the first patterned sacrificial layer comprises photoresist.

210. The method of claim 205 wherein the at least one of the first and second elastomeric layers are formed by spincoating.

211. The method of claim 205 wherein the first recess comprises a channel.

212. The method of claim 205 further comprising bonding the first elastomeric layer to the second elastomeric layer.

213. The method of claim 207 further comprising:

bonding the first elastomeric layer to the second elastomeric layer; and

bonding the third elastomeric layer to the second elastomeric layer.

214. The method of claim 205 wherein at least one of the first elastomeric layer and the second elastomeric layer are formed from a material selected from the group consisting of:

polyisoprene, polybutadiene, polychloroprene, polyisobutylene, poly(styrene-butadiene-styrene), the polyurethanes, and silicones.

215. The method of claim 205 wherein at least one of the first elatomeric layer and the second elastomeric layer are formed from a material selected from the group consisting of:

poly(bis(fluoroalkoxy)phosphazene) (PNF, Eypel-F), poly(carborane-siloxanes) (Dexsil), poly(acrylonitrile-butadiene) (nitrile rubber), poly(1-butene), poly(chlorotrifluoroethylene-vinylidene fluoride) copolymers (Kel-F), poly(ethyl vinyl ether), poly(vinylidene fluoride), poly(vinylidene.fluoride – hexafluoropropylene) copolymer (Viton).

216. The method of claim 205 wherein at least one of the first elastomeric layer and the second elastomeric structure are fabricated from a material selected from the group consisting of:

elastomeric compositions of polyvinylchloride (PVC), polysulfone, polycarbonate, polymethylmethacrylate (PMMA), or polytertrafluoroethylene (Teflon).

217. The method of claim 214 wherein the elastomeric structure is fabricated from a material selected from the group consisting of:

polydimethylsiloxane (PDMS) such as General Electric RTV 615, Dow Chemical Corp. Sylgard 182, 184, or 186, and aliphatic urethane diacrylates such as Ebecryl 270 or Irr 245 from UCB Chemicals.

218. The method of claim 212 wherein the bonding occurs by interpenetration and reaction of the polymer chains of the uncured elastomer with the polymer chains of the cured elastomer.

219. The method of claim 212 wherein the first elastomeric layer has an excess of a first chemical species and the second elastomeric layer has an excess of a second chemical species.

220. The method of claim 219 wherein the first and second chemical species comprise different molecules.

221. The method of claim 219 wherein the first and second chemical species comprise different polymer chains.

222. The method of claim 219 wherein the first and second chemical species comprise different side groups on the same type of polymer chains.

223. The method of claim 219 wherein the first chemical species forms bonds with the second chemical species when at least one chemical species is activated.

224. The method of claim 223 wherein the at least one chemical species is activated by light.

225. The method of claim 223 wherein the at least one chemical species is activated by heat.

226. The method of claim 223 wherein the at least one chemical species is activated by the addition of a third chemical species.

227. The method of claim 226 wherein the at least one chemical species diffuses through the elastomer structure.

228. The method of claim 219 wherein the first and second elastomeric layers are formed of different elastomeric materials.

229. The method of claim 219 wherein the first and second elastomeric layers are initially composed of the same elastomeric material, and an additional elastomeric material is added to one of the first and second layers.

230. The method of claim 219 wherein the first and second elastomeric layers are composed of the same component materials but differ in the ratio in which the component materials are mixed together.

231. The method of claim 230 wherein each of the elastomeric layers is made of two-part silicone.

232. The method of claim 231 wherein each elastomeric layer comprises an addition cure elastomer system.

233. The method of claim 231 wherein the silicone comprises two different reactive groups and a catalyst.

234. The method of claim 233 wherein the first reactive group comprises silicon hydride moieties, the second reactive group comprises vinyl moieties, and the catalyst comprises platinum.

235. The method of claim 234 wherein each elastomeric layer comprises G.E. RTV 615.

236. The method of claim 235 wherein the first elastomeric layer is mixed with a ratio of less than 10A:1B (excess Si-H groups) and the second elastomeric layer is mixed with a ratio of more than 10A:1B (excess vinyl groups).

237. The method of claim 229 wherein the first elastomeric layer has a ratio of 3A:1B (excess Si-H groups) and the second elastomeric layer has a ratio of 30A:1B (excess vinyl groups).

238. The method of claim 219 wherein each of the elastomeric layers are made of polyurethane.

239. The method of claim 238 wherein the polyurethane comprises Ebecryl 270 or Irr 245 from UCB Chemicals.

240. The method of claim 212 wherein the first and second elastomeric layers are made of the same material.

241. The method of claim 240 wherein at least one of the first and second elastomeric layers are incompletely cured.

242. The method of claim 240 wherein the first and second elastomeric layers include a crosslinking agent.

243. The method of claim 242 wherein the crosslinking agent is activated by light.

244. The method of claim 242 wherein the crosslinking agent is activated by heat.

245. The method of claim 242 wherein the crosslinking agent is activated by an additional chemical species.

246. The method of claim 212 wherein the elastomeric layers comprise thermoset elastomers which are bonded together by heating above an elastic/plastic transition temperature of at least one of the first and second elastomeric layers.

247. The method of claim 205 wherein at least one of the first elastomeric layer and the second elastomeric layer further comprise a conductive portion.

248. The method of claim 247 wherein the conductive portion is made by metal deposition.

249. The method of claim 247 wherein the conductive portion is made by sputtering.

250. The method of claim 247 wherein the conductive portion is made by evaporation.

251. The method of claim 248 wherein the conductive portion is made by electroplating.

252. The method of claim 248 wherein the conductive portion is made by electroless plating.

253. The method of claim 248 wherein the conductive portion is made by chemical epitaxy.

254. The method of claim 247 wherein the conductive portion is made by made by carbon deposition.

255. The method of claim 254 wherein the conductive portion is made by mechanically rubbing material directly onto the elastomeric layer.

256. The method of claim 254 wherein the conductive portion is made by exposing the elastomer to a solution of carbon particles in solvent.

257. the method of claim 256 wherein the solvent causes swelling of the elastomer.

258. The method of claim 256 wherein the elastomer comprises silicone and the solvent comprises a chlorinated solvent.

259. The method of claim 254 wherein the conductive portion is made by electrostatic deposition.

260. The method of claim 254 wherein the conductive portion is made by a chemical reaction producing carbon.

261. The method of claim 247 wherein the conductive portion is made by:

patterning a thin layer of metal on a flat substrate;

adhering the elastomeric layer onto the flat substrate; and

peeling the elastomeric layer off the flat substrate, such that the metal sticks to the elastomeric layer and comes off the flat substrate.

262. The method of claim 261 wherein the adhesion of the metal to the flat substrate is weaker than the adhesion of the metal to the elastomer.

263. Method of claim 247 wherein the conductive portion is patterned.

264. The method of claim 262 wherein the conductive portion is patterned by masking a surface of the conductive portion with a patterned sacrificial material.

265. The method of claim 262 wherein the conductive portion is patterned by:

depositing a sacrificial material on one of the elastomeric layers,
patterning the sacrificial material,
depositing a thin coat of conductive material thereover, and
removing the sacrificial material.

266. The method of claim 262 wherein the conductive portion is patterned by masking the surface with a shadow mask.

267. The method of claim 266 wherein the conductive portion is patterned by:

positioning a shadow mask adjacent to elastomeric layer;
depositing a thin coat of conductive material through apertures in the shadow mask; and
removing the shadow mask.

268. The method of claim 262 wherein the conductive portion is patterned by etching.

269. The method of claim 268 wherein the conductive portion is patterned by:

depositing a mask layer onto one of the elastomeric layers;
patterning the mask layer;
etching the conductive portion through holes in the mask layer; and
removing the mask layer.

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270. The method of claim 250 wherein the conductive portion is produced by doping the elastomer with a conductive material.

271. The method of claim 270 wherein the conductive material comprises a metal.

272. The method of claim 270 wherein the conductive material comprises carbon.

273. The method of claim 270 wherein the conductive material comprises a conductive polymer.

274. The method of claim 269 wherein the elastomer is inherently conductive.

275. The method of claim 247 further comprising sealing the microfabricated structure on a flat surface, wherein the flat surface comprises at least one conductive portion.

276. The method of claim 275 wherein the flat substrate is covered by an insulating layer.

277. The method of claim 205 wherein at least one of the first or second elastomeric layers comprises a magnetic portion.

278. The method of claim 277 wherein the magnetic portion is composed of an intrinsically magnetic elastomer.

279. The method of claim 277 wherein the magnetic portion is composed of an elastomer doped with a magnetic material.

280. The method of claim 279 wherein the magnetic dopant is a magnetically polarizeable material.

281. The method of claim 280 wherein the magnetic dopant is fine iron particles.

282. The method of claim 279 wherein the magnetic dopant is permanently magnetized.

283. The method of claim 282 wherein the magnetic dopant is NdFeB or SmCo magnetized by exposure to a high magnetic field.

284. The method of claim 277 wherein pieces of magnetic material are relatively large compared with the size of the magnetic portion are incorporated into the elastomer.

285. The method of claim 284 wherein the magnetic material is a magnetically polarizeable material.

286. The method of claim 285, wherein the magnetic material is iron.

287. The method of claim 284, wherein the magnetic material is permanently magnetized.

288. The method of claim 287, wherein the permanently magnetic material is NdFeB or SmCo magnetized by exposure to a high magnetic field.

289. The method of claim 286, further comprising providing a structure capable of generating a switchable magnetic field, disposed adjacent to said magnetic portion, such that the application of said magnetic field to the elastomeric structure causes the generation of a force on the magnetic portion.

290. The method of claim 286, wherein the structure generating the magnetic field is a magnet coil.

291. The method of claim 286, wherein the structure generating the magnetic field is a substrate with at least one microfabricated magnet coil disposed thereon.